EVALUATING AIRBORNE LASER SCANNING FOR GULLY EROSION DETECTION AND BASELINE MAPPING IN THE FITZROY CATCHMENT, QLD, AUSTRALIA

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1. Introduction

Australia's climate and land management practises have resulted in an increased threat to land condition and water quality through sediment transported by gully erosion. The Fitzroy River catchment is located in Queensland and is the largest catchment on the east coast of Australia. It covers approximately 14.26 million hectares and drains into the Great Barrier Reef lagoon. Grazing is the major land use of the Fitzroy River catchment (80.93%), followed by cropping (6.2%) (Rowland *et al.*, 2006). Changes to land use over time as population has increased in the region has led to a decline in water quality (Dougall *et al.,* 2006).

Water quality modelling (Prosser *et al.*, 2001; Wilkinson *et al.*, 2004; McKergow *et al.*, 2005; Dougall *et al.*, 2005; Joo *et al.*, 2005;) has shown that gully erosion is likely to be the main source of sediment for the Fitzroy. However, the uncertainty in these models is substantial (Dougall *et al.,* 2006). A major limitation is that gully densities, volumes, types and locations have not been accurately mapped and modelled to date at an appropriate scale.

Two concurrent projects are in progress to improve the spatial information on gullies for the Fitzroy River catchment: The Short-Term Modelling Project (Dougall *et al.*, 2006) aims to refine estimates of gully density by digitising gullies on Quickbird satellite imagery for sample areas and to extrapolate across the catchment from the sample sites using a range of environmental variables. The second project, described in this paper, is developing methods to detect and map gullies using Light Detection and Ranging (LIDAR) technology in the form of an aeroplane mounted Airborne Laser Scanner (ALS). The expected outcomes are (i) improved information on gully volume for areas sampled with ALS data; and (ii) accurate baseline datasets for future monitoring for sampled gullies. The paper will briefly outline the methods and products created from LIDAR derived Digital Elevation Models (DEM) to date.

2. Methods

2.1. Airborne Laser Scanner data

LIDAR has the potential to map gullies at a fine yet precise and accurate resolution. The fact it can also accurately measure height means there is a potential for gully volume changes to be detected over time.

Five sites were chosen within the Fitzroy catchment (Fig. 1a,b), mainly within the Nogoa sub-catchment, a region found to have the largest gully density in previous sediment movement prediction models (Dougall *et al.*, 2006).

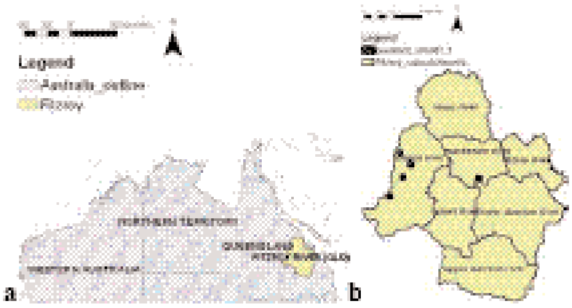

Fig. 1a: Location of Fitzroy catchment within Queensland, Australia. Only the northern states of Australia are shown.
Fig. 1b: Location of 5 study sites within the Fitzroy catchment, Queensland, Australia. Two LIDAR transects of 5km x 200m each were captured for each site.

On February 3-5, 2007 ten LIDAR transects were flown over five sites in total using an Optech ALS ALTM 3100 Enhanced Accuracy LIDAR scanner to capture easting (X), northing (Y) and height (Z) data. Two 5km x 300m transects in a cross design with an average laser point density of 30cm for each transect were captured. The transect design allows quantification of errors over time.

Quickbird imagery was also acquired over the five sites to optically validate and assess the LIDAR data. 3-D analysis in ArcScene 9.2 aided in the visual delineation of gullies.

2.2. Digital Elevation Model visualisation

We acquired the raw LIDAR data in the format of a *.las* file. The LIDAR data was classified into ground and non-ground returns by the 'Terrascan' classification system. The ground return files were imported into ArcMap 9 to create point files from text files and then Digital Elevation Models (DEMs) were created using the inverted distance weighted (IDW) interpolation algorithm in ArcMap 9.

2.3. Field validation

Surveyors recorded 118 measurements on February 7th, 2007 along one of the ten transects to assess the accuracy of the LIDAR captured. On March 5th, 2007, a field trip was conducted to validate the LIDAR transects. Photos, GPS points and bearings were recorded for four transects, with more field trips planned for additional validation. The field

IV International Symposium on Gully Erosion. J. Casalí and R. Giménez (Eds.)
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data was used to validate the 'edge' of the gullies and to assess the accuracy of the automated 'Terrascan' classification.

3. Results

3.1. Digital Elevation Model visualisation

DEMs with a 50cm spatial resolution (pixel size) were generated for each of the 10 transects. Two examples, clearly showing gullies are shown in Figures 2a,b representing two different 1500m subsets.

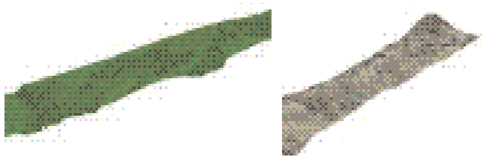

Fig. 2a: Gullies identified in the 30cm DEM over a 1500m subset created from LIDAR Transect 2 data (vertically exaggerated 5 times). **Fig. 2b:** Transect 3 DEM subset with a clipped Quickbird image draped on top (vertically exaggerated 2 times).

Cross-sectional analysis provides valuable information on gully status (Fig. 3). This product can be used to detect gully morphological changes over time.

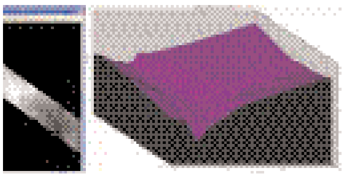

Fig. 3: Cross-sectional analysis of gullies within Transect 2. Elevations of 400 metres to 450 metres above sea level.

3.2. Field validation

Surveyors identified a vertical mean difference of 0.091m (0.045m RMS error) between the surveyed heights and the LIDAR heights. In the regions of overlap of the laser transects, no differences in elevation were recorded. Field photos were linked in ArcMap to points on the transects (Fig. 4). Field photos revealed the LIDAR was accurately classified, despite potential complications such low lying shrubs.

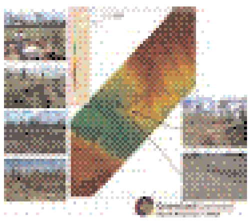

Fig. 4: Transect 3 field photos and coordinates mapped.

4. Discussion

4.1. Current research and future directions

We have established a methodology to capture LIDAR, and visualise the data to detect and measure gullies on an extremely fine scale. In addition, a baseline has been established for future research into sedimentation rates and gully morphology. This will contribute to understanding sedimentation rates in models applicable to the Australian environment and assist in land management and water quality decision making for sustainable use of our resources.

This project only recently commenced and is at an early stage. LIDAR data will be captured for a further ten transects to provide samples over land types not previously covered. The use of object-oriented classification software (Definiens, 2006) will be investigated in an effort to determine gully densities and establish an average density per land type per land use. Results will be published at a later date. Further aspects of this research will analyse 3-dimensional slope and cross-sectional gully types to gain an insight into whether a gully is active as a transport mechanism for sediment movement through the catchment.

We also aim to build on current gully density models and provide (i) improved estimates of gully volume across the catchment; and (ii) if possible, enhanced information on gully status or rate of change. This information will drastically improve sedimentation rate modelling techniques.

The longer term aim is to provide improved information on gully density, volume and status for other priority catchments in Queensland. Therefore it is critical that the approach developed is robust, repeatable and affordable.

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